Robotic Production of Biomimetic Composites

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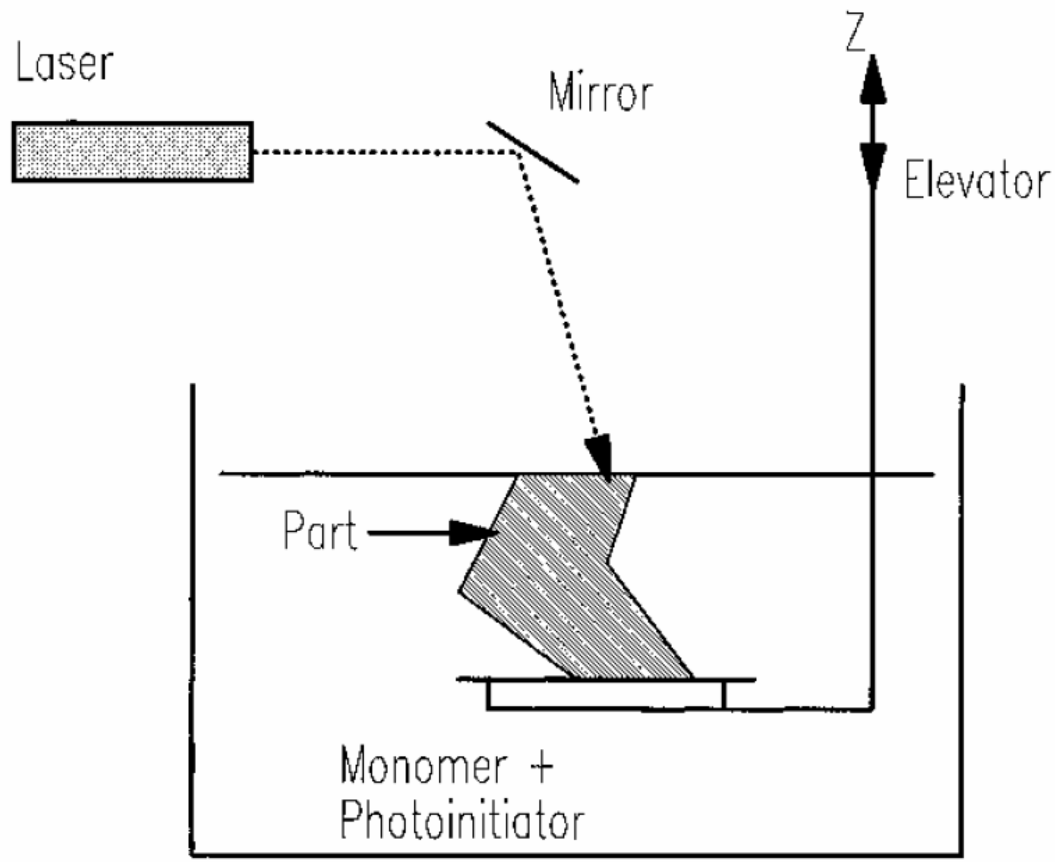
Rapid prototyping
Freeform fabrication
Multimaterial, multilayer fabrication

Rapid prototyping

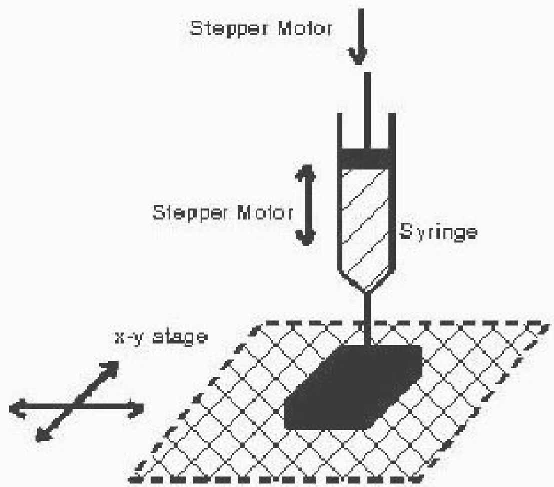
Build a part directly from a 3D CAD drawing

Stereolithography
Fused deposition modeling
3D printing
and others

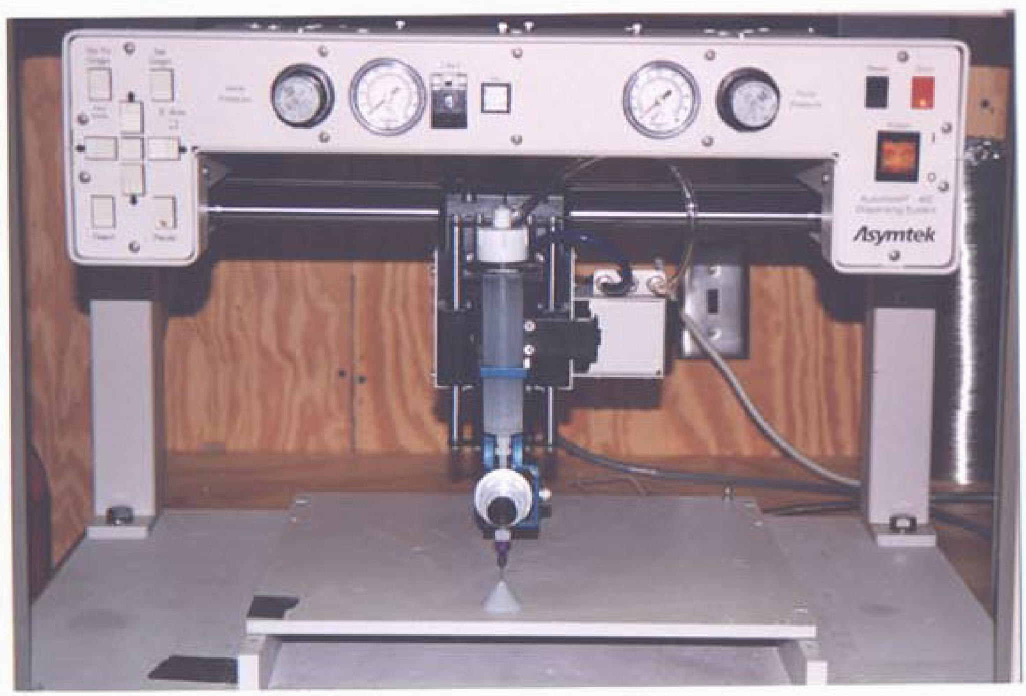
Most do one material at a time
Most do parts with low strength



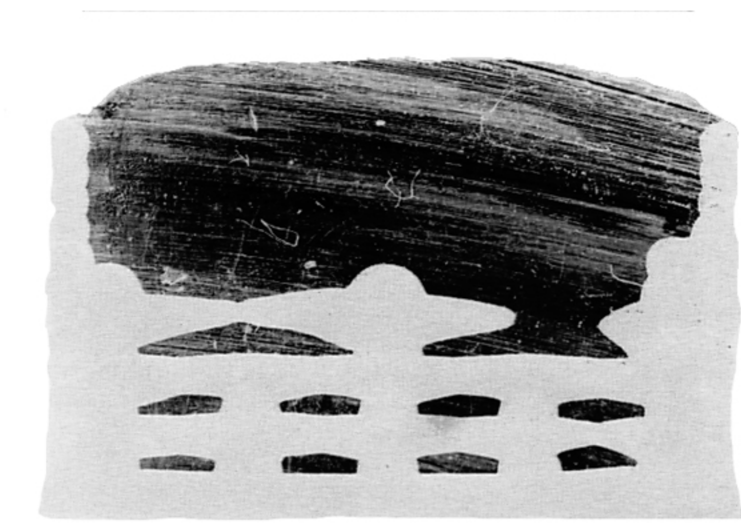
Stereolithography

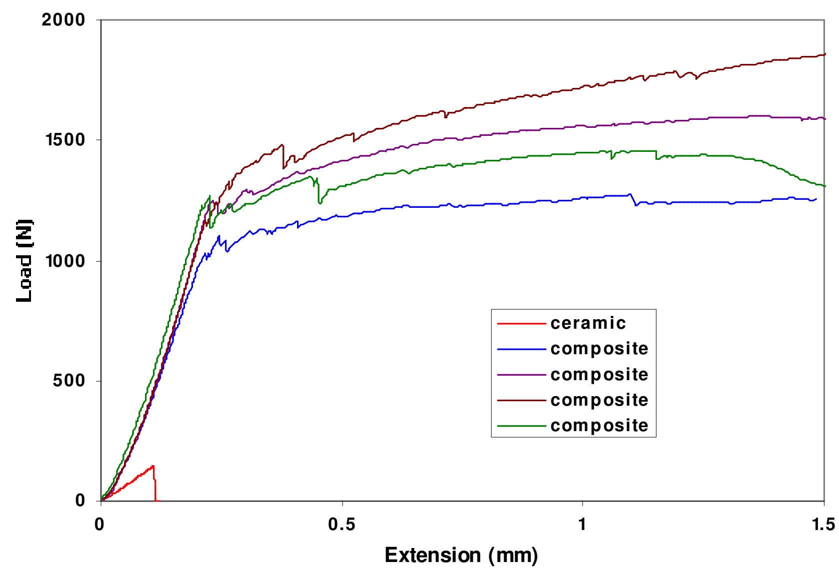


Sketch of freeforming apparatus (left) and freeformed samples including hydrogel (back), composites, alumina, silicon nitride, thermoplastics, aluminum and chocolate.

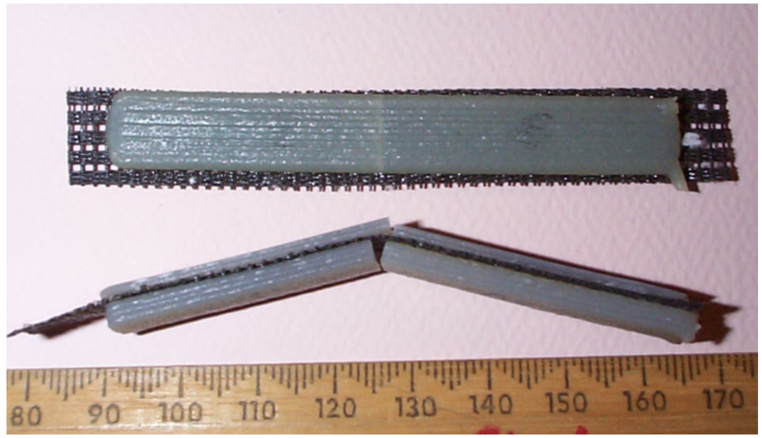


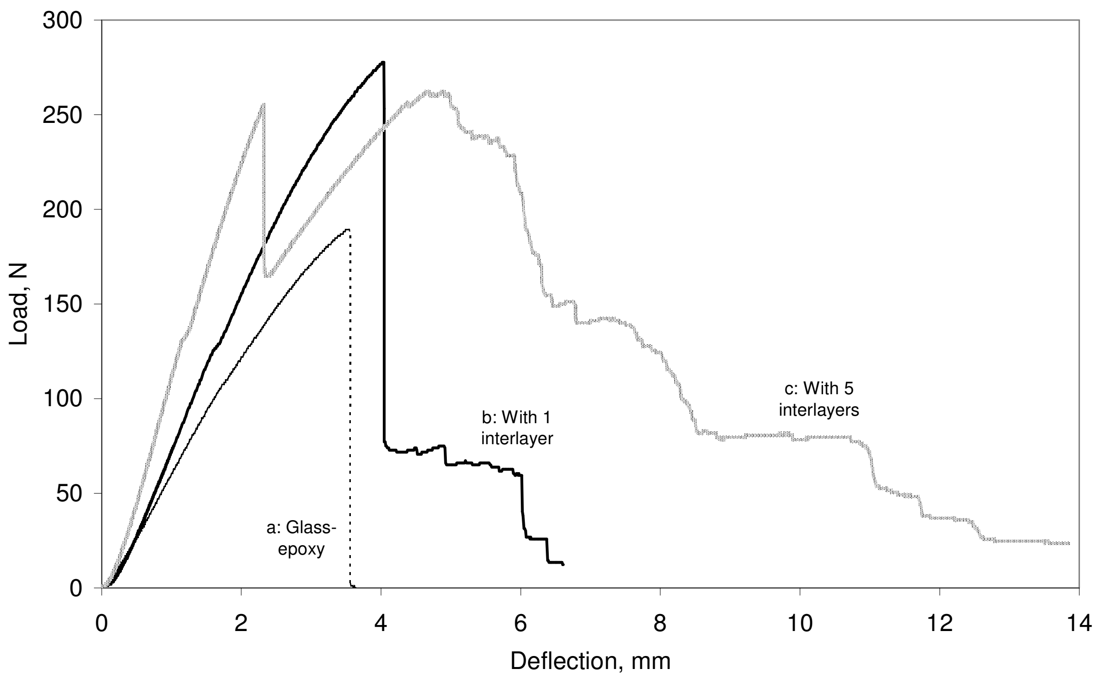
Cross-section of metal-ceramic composite fabricated by Robocasting of alumina ceramic followed by subsequent aluminum metal infiltration, contrast of the ceramic region altered. The metal phase is seen to wet the ceramic phase completely forming an interpenetrating structure. The resulting metal-ceramic combination is much tougher than pure ceramic.



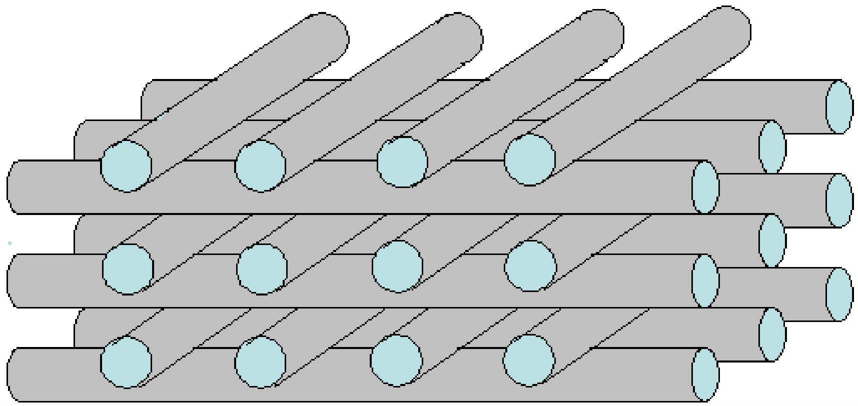


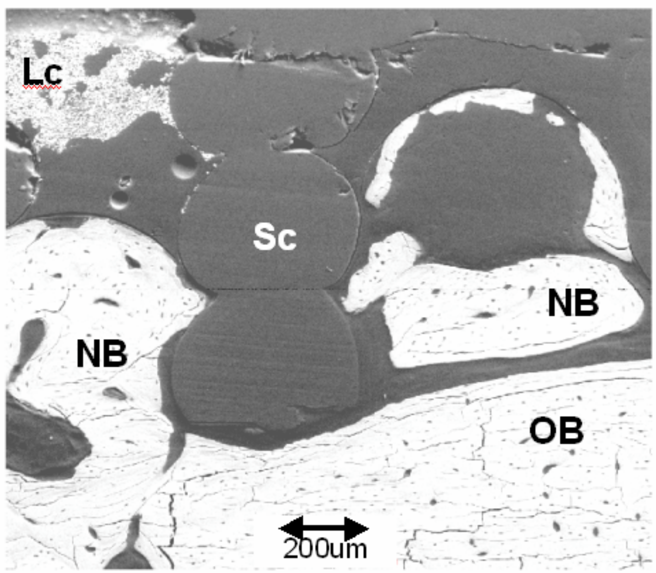
Putting tough layers into epoxy composites enhances the toughness





Biodegradable “logpile” coated with tricalcium phosphate as a porous bone implant. Rat tests.





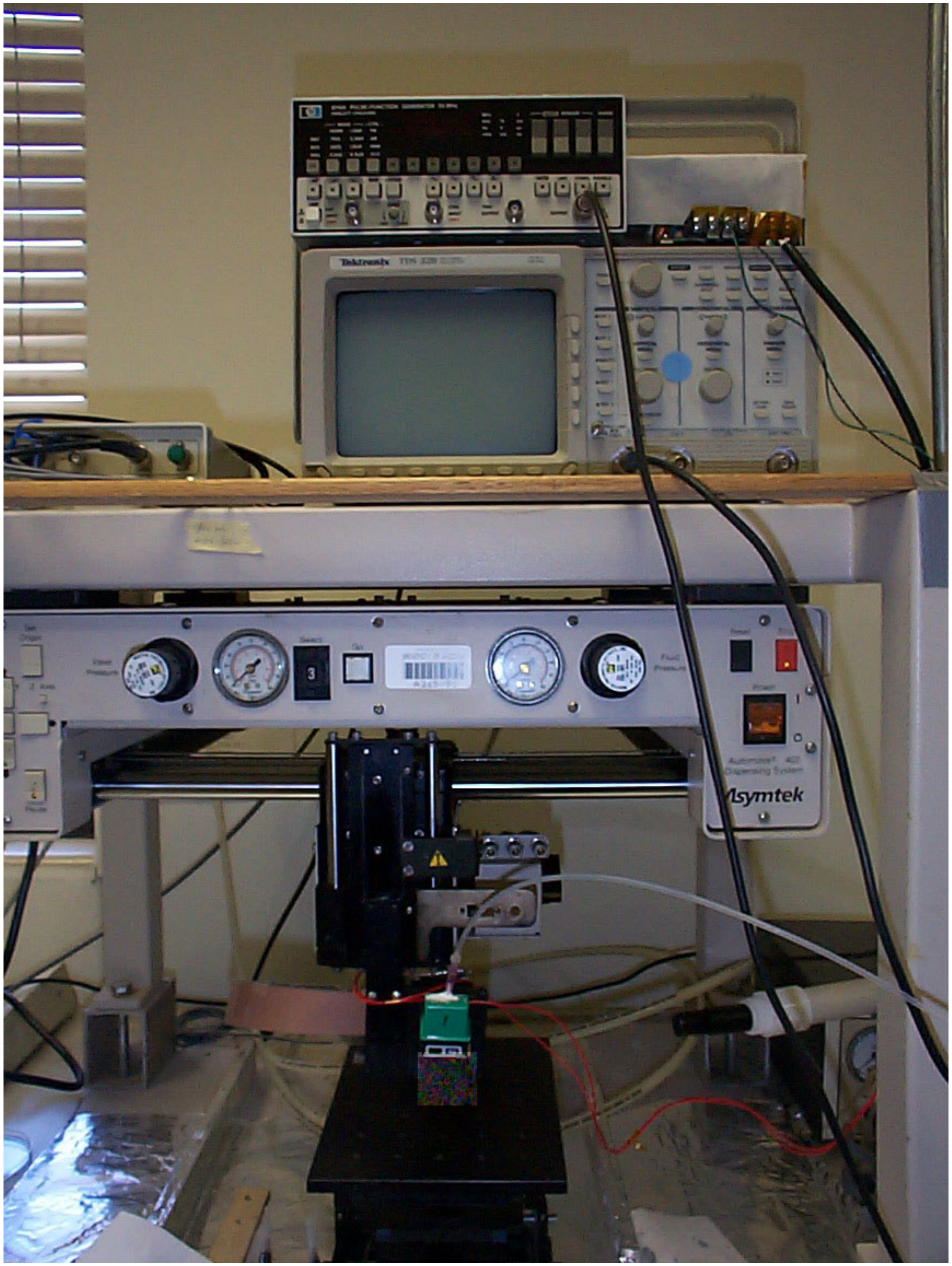
Environmental SEM of implant transverse section

OB – Old Bone
NB – New bone
Sc – PBT Scaffold
Lc – PCL/TCP latex remnant

- Test coupon attached to femoral surface, allowed 4 months of ingrowth
- Bone ingrowth into pores clearly evident
- Osteons, haversian canals visible in NB

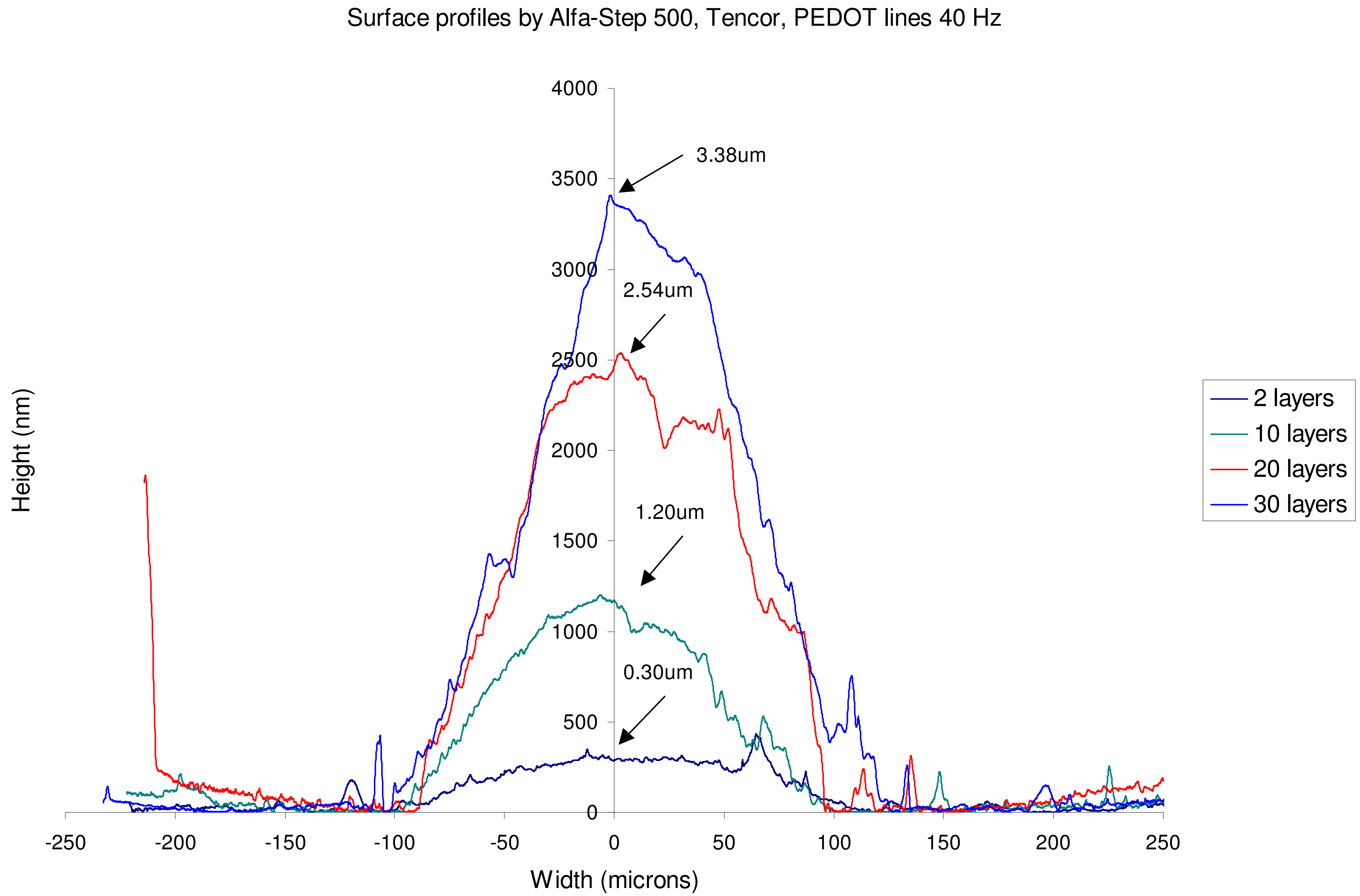
Inkjet printing for higher resolution

Printing PEDOT transparent conductors for OLEDs

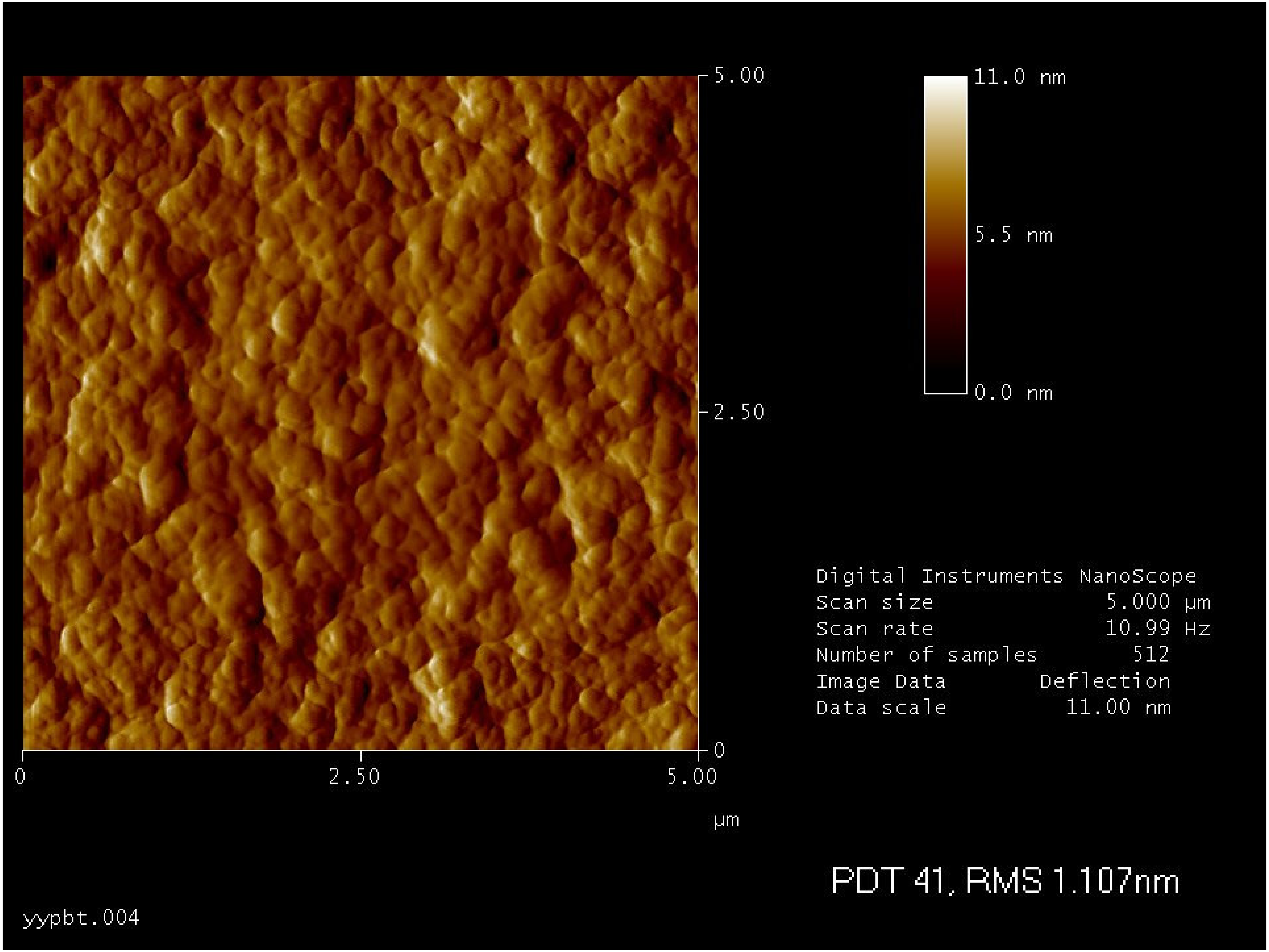


Pulse generator drives home-made current source, pulse a single nozzle.

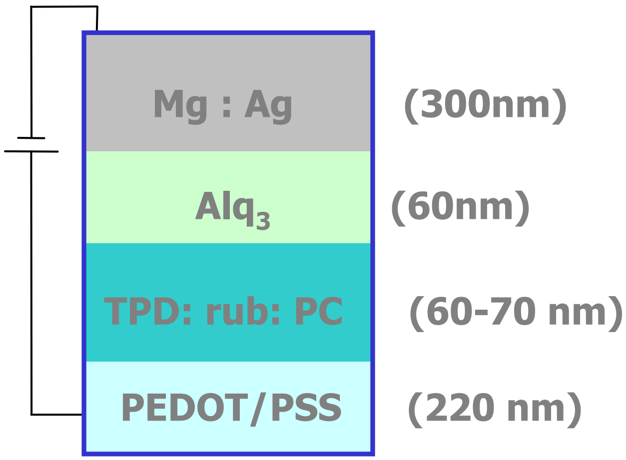
Controlled vacuum prevents dripping



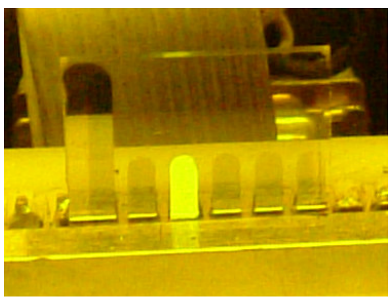
Overprinting a single line. Width does not change.
Resistivity 10^{-2} Ω.m

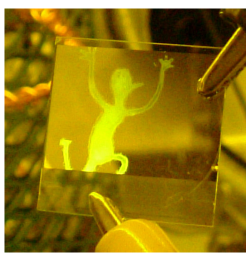

5.00
2.50
0
0
2.50
5.00
µm
11.0 nm
5.5 nm
0.0 nm
Digital Instruments NanoScope
Scan size 5.000 µm
Scan rate 10.99 Hz
Number of samples 512
Image Data Deflection
Data scale 11.00 nm
PDT 41, RMS 1.107nm
yypbt.004

OLED characteristics

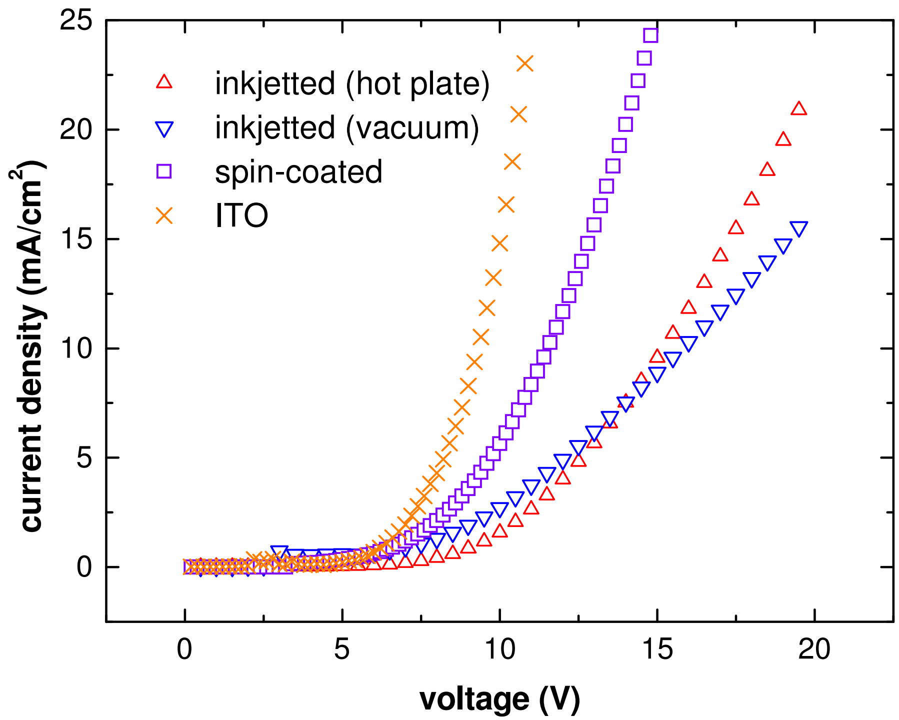


surface resistivity = 1800 Ω/sq.
conductivity = 25 S/cm

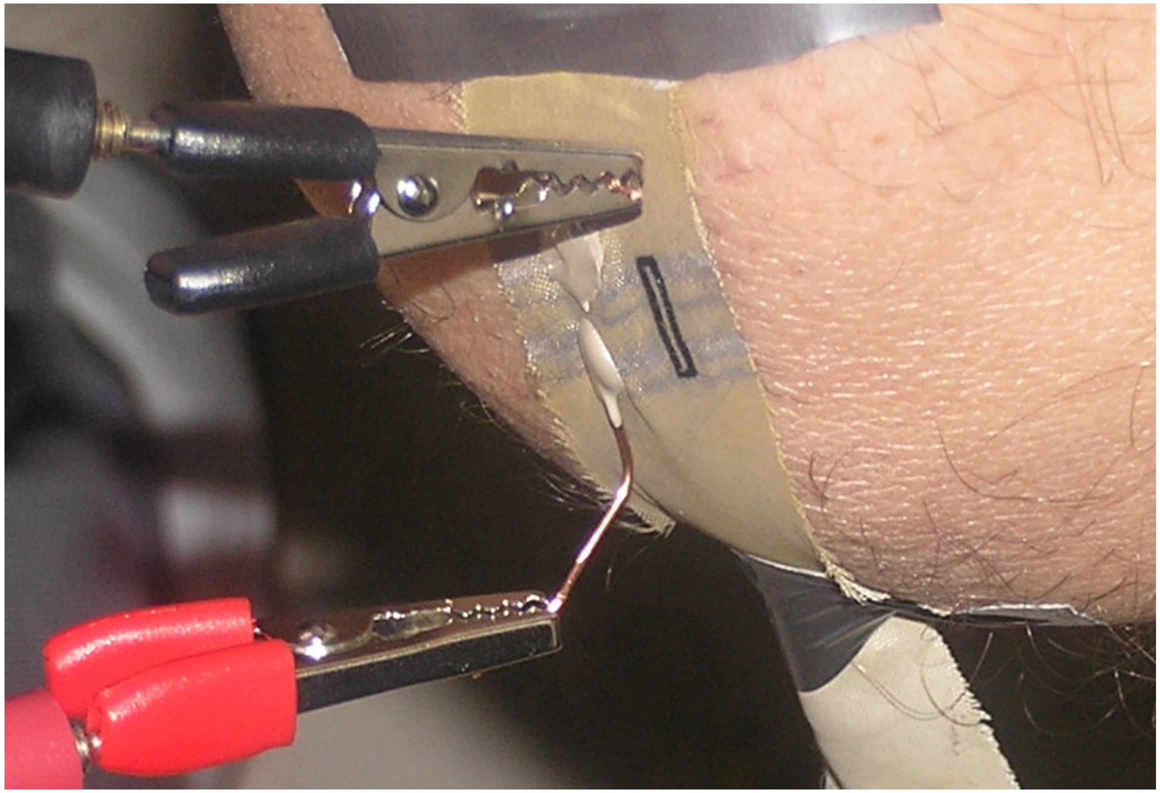




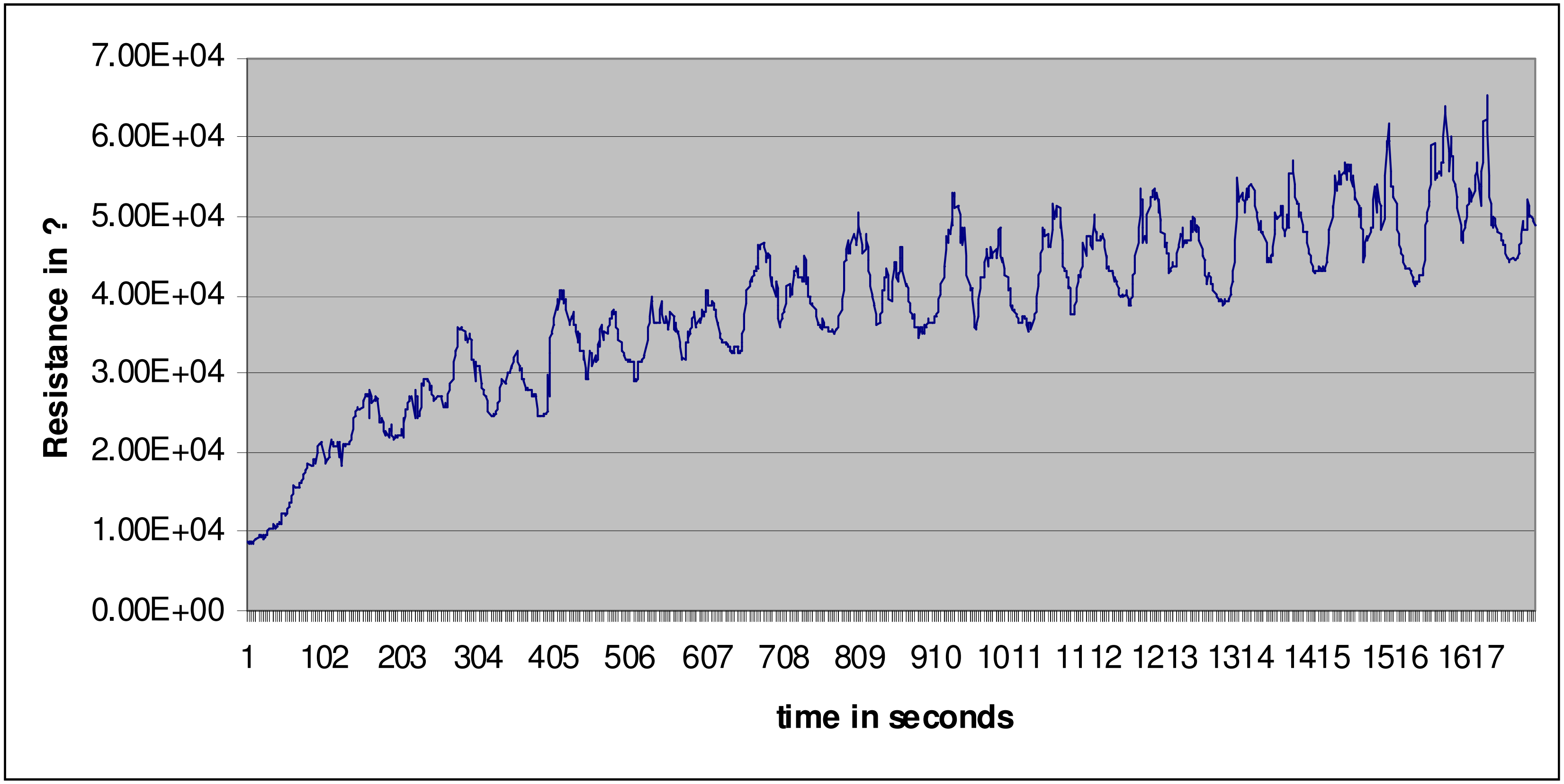
current density



Printing strain sensors and chemical sensors onto textiles



Strain sensor on a knee

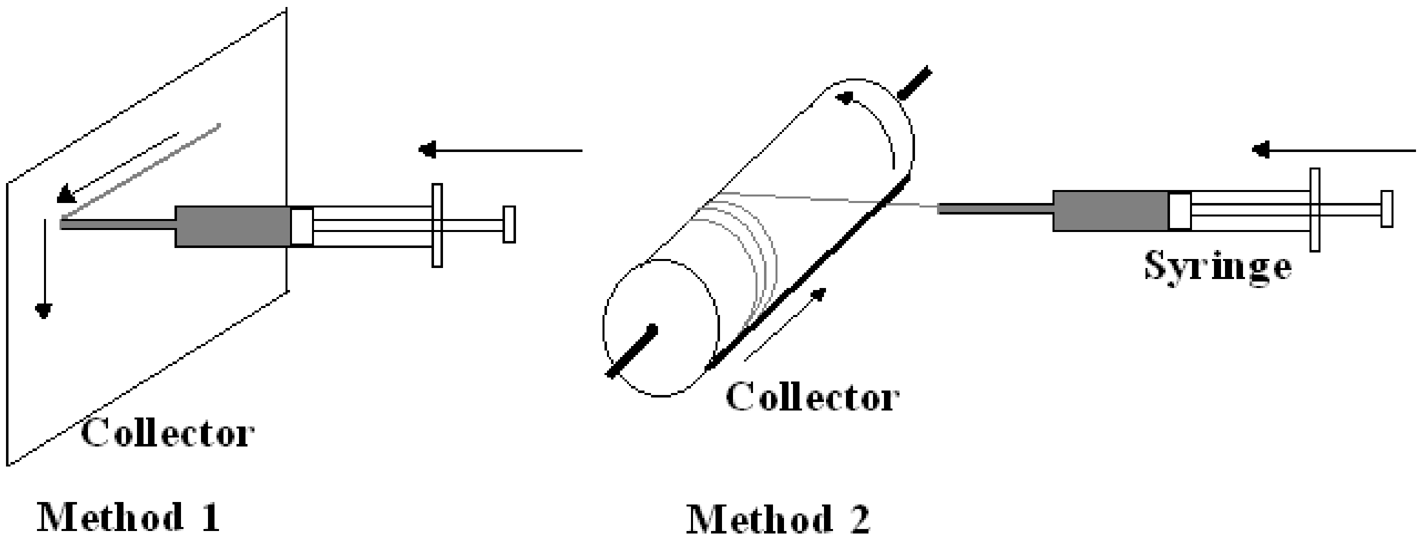


Variation in Resistance of PEDOT-PSS coated fabrics vs time within 25 repeated cycles of 5% strain and relaxation

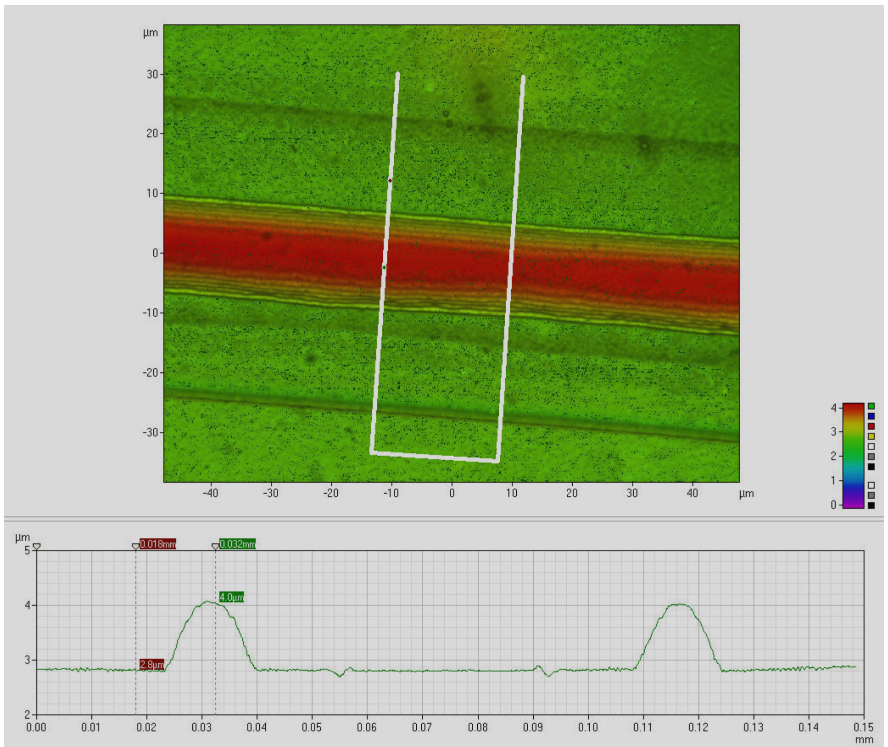
The Robospider

Develop methods to deposit fibers from small amounts of solution of valuable polymers, for electronic or biomedical applications.

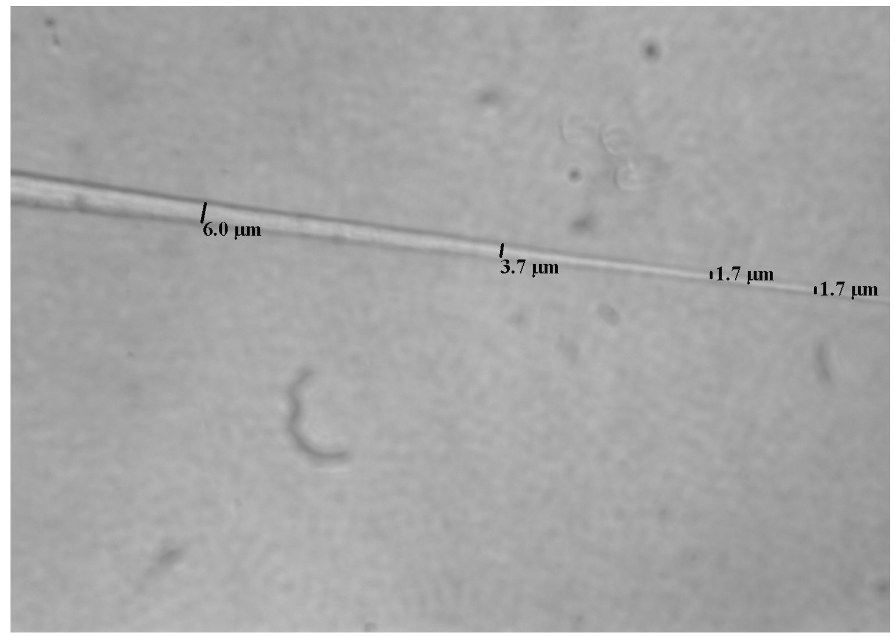
Fibers can be written onto a surface or pulled onto a drum



Fiber written onto glass
100 microns wide, 1 micron high



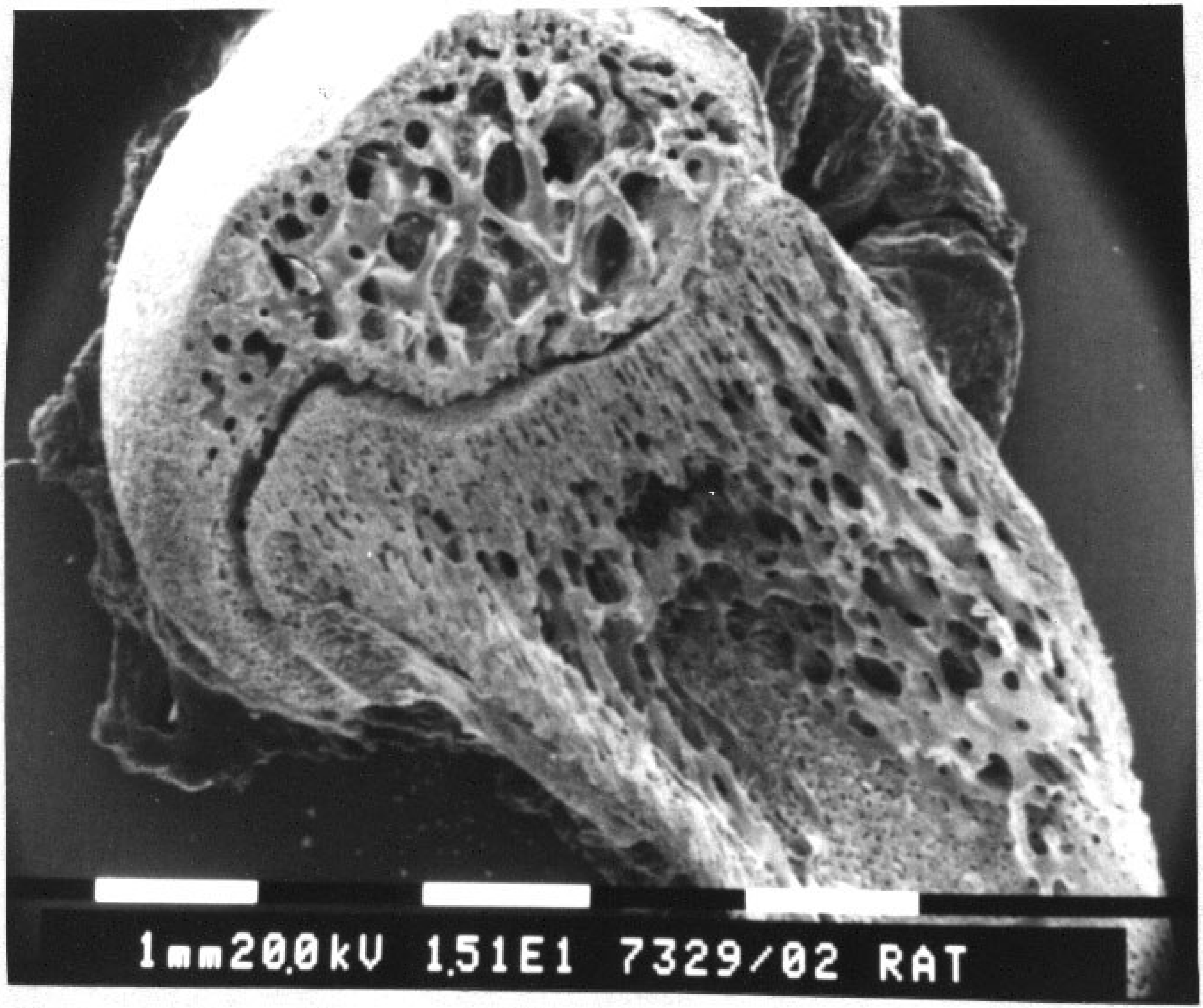
2 micron pulled fiber



Put all these methods together to write
fibers, resins, gels, conductors and devices
into a single system.

This is what happens during biological growth

Rat Bone with Growth Plate

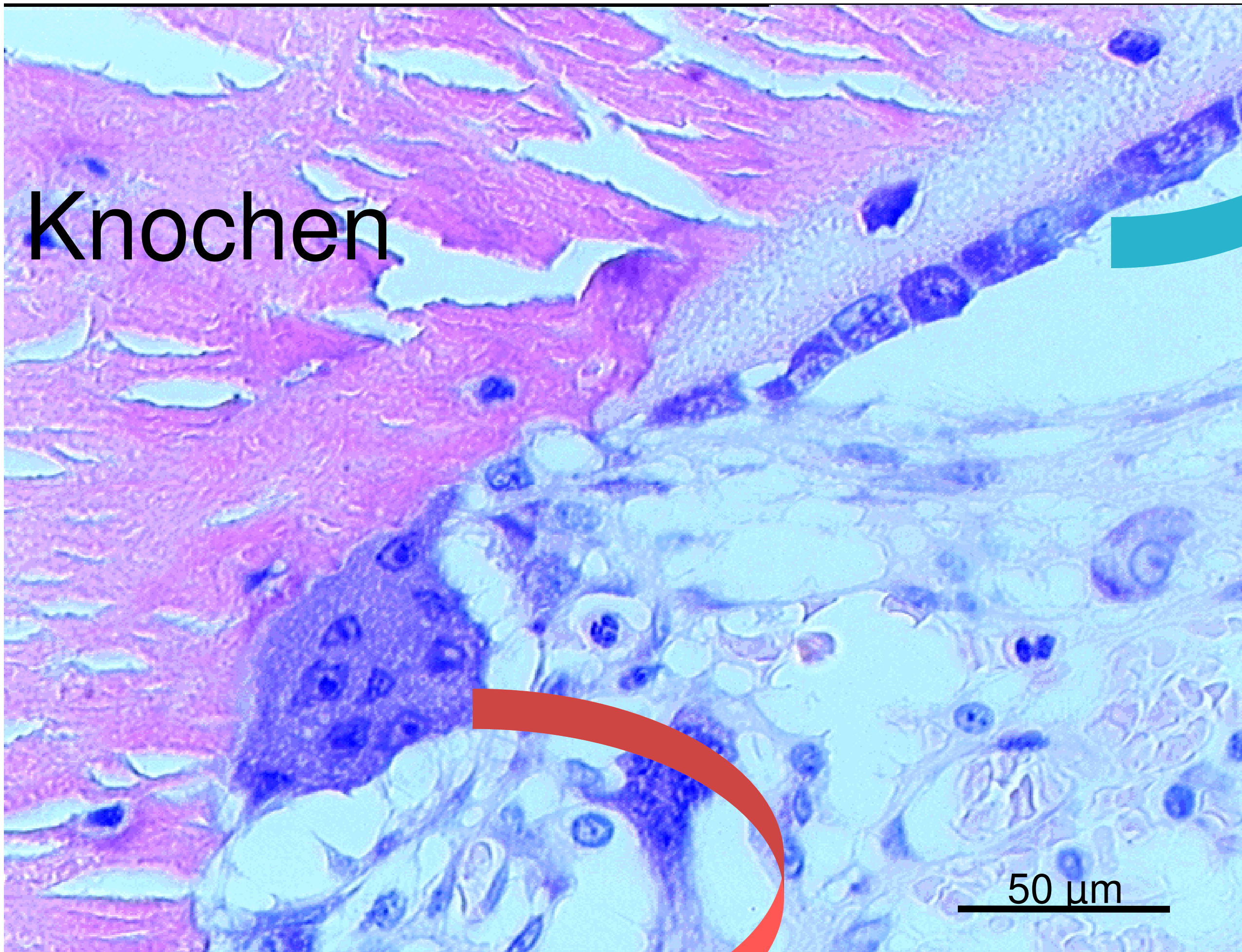


Bone cells

(Light microscopy, Giemsa)

formation

Osteoblasts



resorption

Osteoclasts

These robotic methods cannot compete for speed with conventional molding
They do compete with metal machining

and:
the parts are customizable
the equipment can be small
the functionality of the parts can be high

Thanks for support to:

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DoD for equipment